ARHITECTURA SISTEMELOR DE CALCUL - CURS 0x07

DE LA COD SURSĂ LA EXECUȚIE

Cristian Rusu

CUPRINS

- **scurt review arhitectura de bază a calculatoarelor**

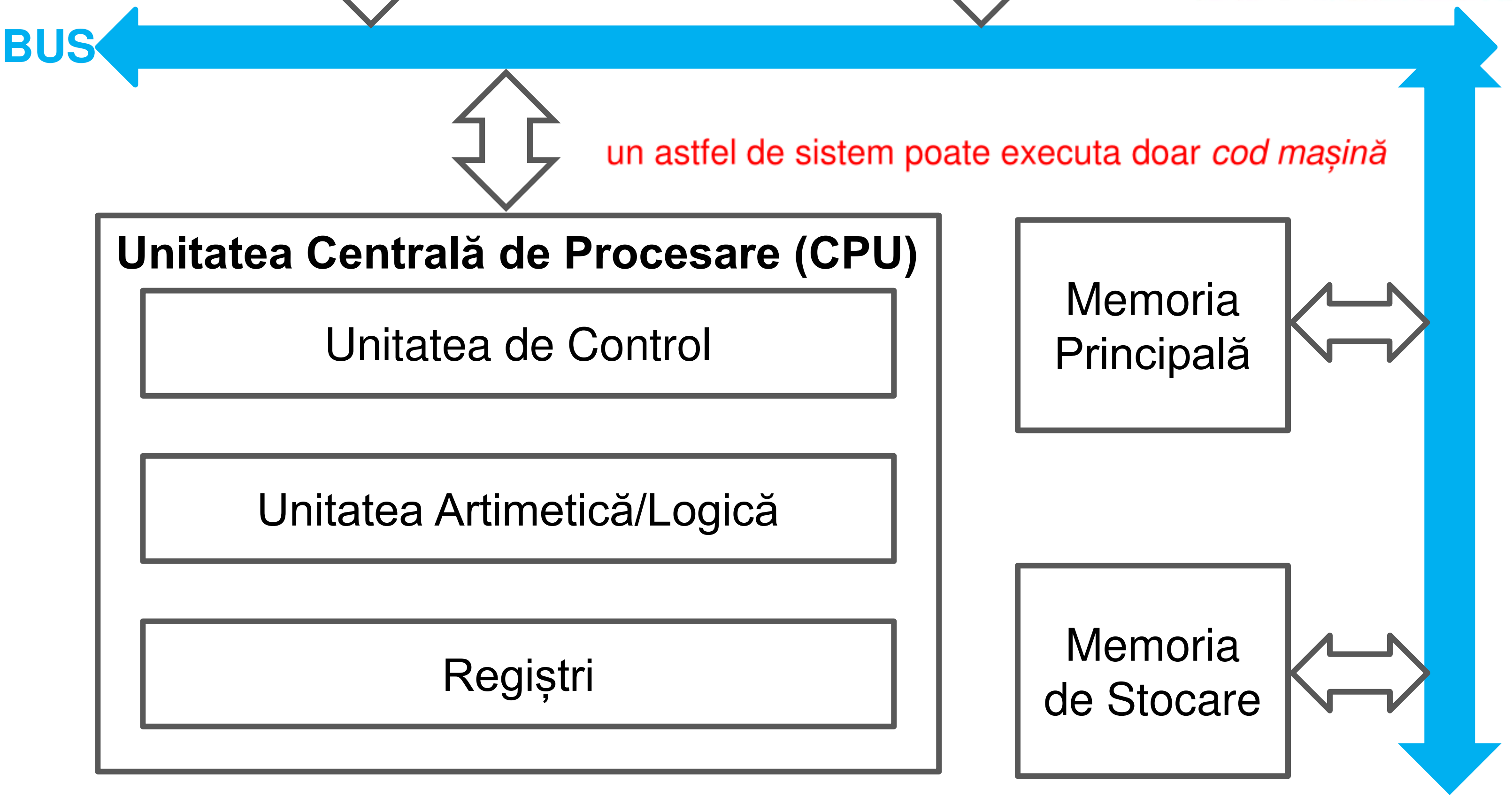
- **Instruction Set Architecture (ISA)**

- **de la cod sursă la cod mașină**
    - software cracking
    - executarea datelor

ARHITECTURA DE BAZĂ

Periferice Intrare

Periferice Ieșire



BUS

un astfel de sistem poate executa doar *cod mașină*

Unitatea Centrală de Procesare (CPU)

Unitatea de Control

Unitatea Artimetică/Logică

Regiștri

Memoria Principală

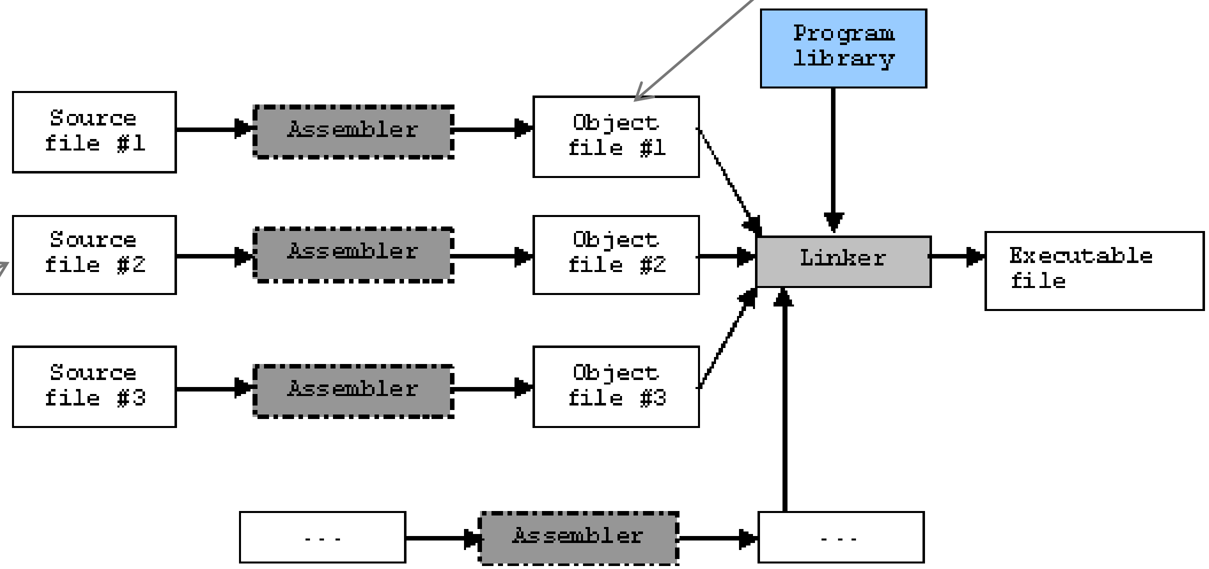
Memoria de Stocare

comunicarea cu perifericele se face de obicei prin buffer-e în memorie

DE LA COD SURSĂ LA EXECUȚIE

- **cod mașină (machine code)**
  - instrucțiuni binare executate direct de CPU
  - CPU poate executa doar cod mașină (orice altceva e tradus în CM)
  - cum obține cod mașină?
    - din cod sursă
    - codul sursă este generic
    - codul mașină e specific pentru Assembler, CPU, OS

cod mașină



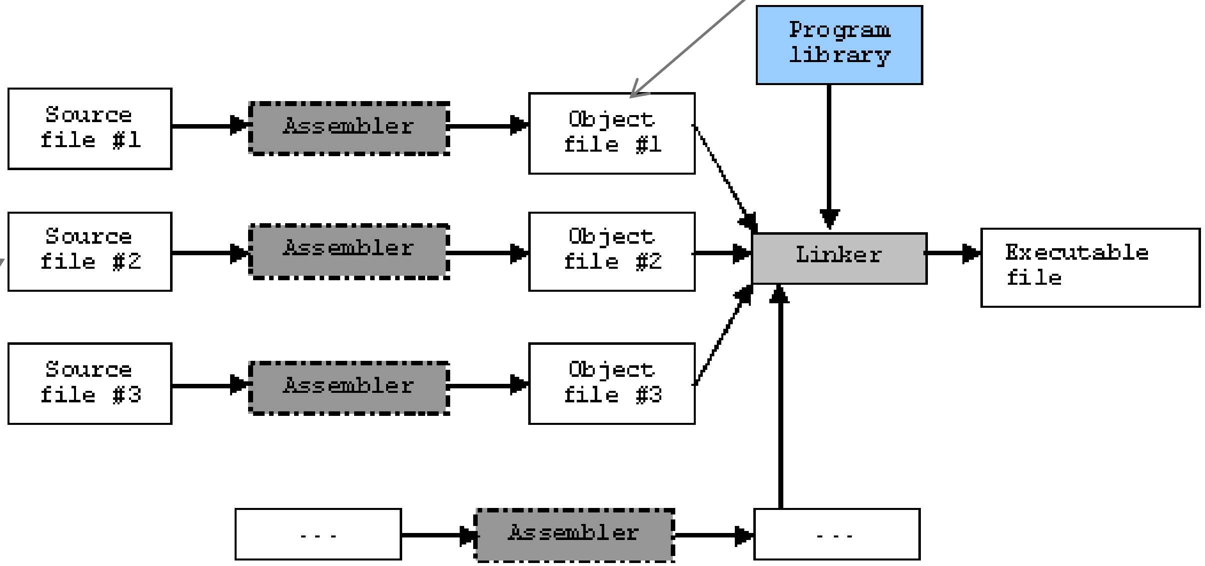
ASM

https://en.wikipedia.org/wiki/C_standard_library

DE LA COD SURSĂ LA EXECUȚIE

- **cod mașină (machine code)**
  - la laborator, primul vostru program ASM a fost:
    - as --32 program_exit.asm -o program_exit.o
    - ld -m elf_i386 program_exit.o -o program_exit
    - ./program_exit
- la laborator, pentru programele ASM unde ați folosit scanf/printf:
  - as --32 matrix.asm -o matrix.o
  - gcc –m32 matrix.o -o matrix
  - ./matrix

cod mașină

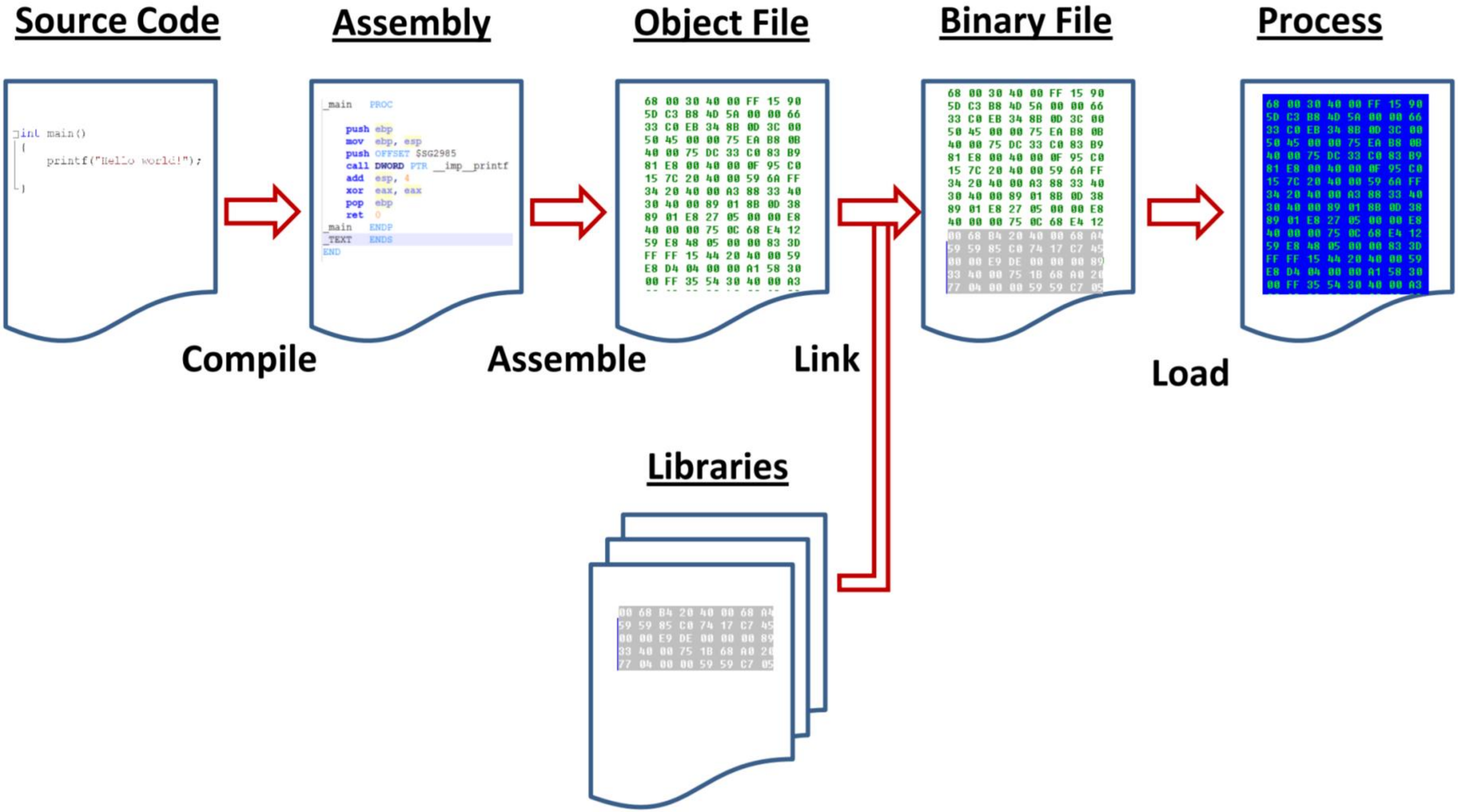


ASM

https://www.tenouk.com/ModuleW.html

DE LA COD SURSĂ LA EXECUȚIE

- în general (nu doar pentru Assembly)



```
int main()
{
    printf("Hello world!");
}
```

```
_main   PROC

    push ebp
    mov  ebp, esp
    push OFFSET $SG2985
    call DWORD PTR __imp__printf
    add  esp, 4
    xor  eax, eax
    pop  ebp
    ret  0
_main   ENDP
_TEXT   ENDS
END
```

```
68 00 30 40 00 FF 15 90
5D C3 B8 4D 5A 00 00 66
33 C0 EB 34 8B 0D 3C 00
50 45 00 00 75 EA B8 0B
40 00 75 DC 33 C0 83 B9
81 E8 00 40 00 0F 95 C0
15 7C 20 40 00 59 6A FF
34 20 40 00 A3 88 33 40
30 40 00 89 01 8B 0D 38
89 01 E8 27 05 00 00 E8
40 00 00 75 0C 68 E4 12
59 E8 48 05 00 00 83 3D
FF FF 15 44 20 40 00 59
E8 D4 04 00 00 A1 58 30
00 FF 35 54 30 40 00 A3
```

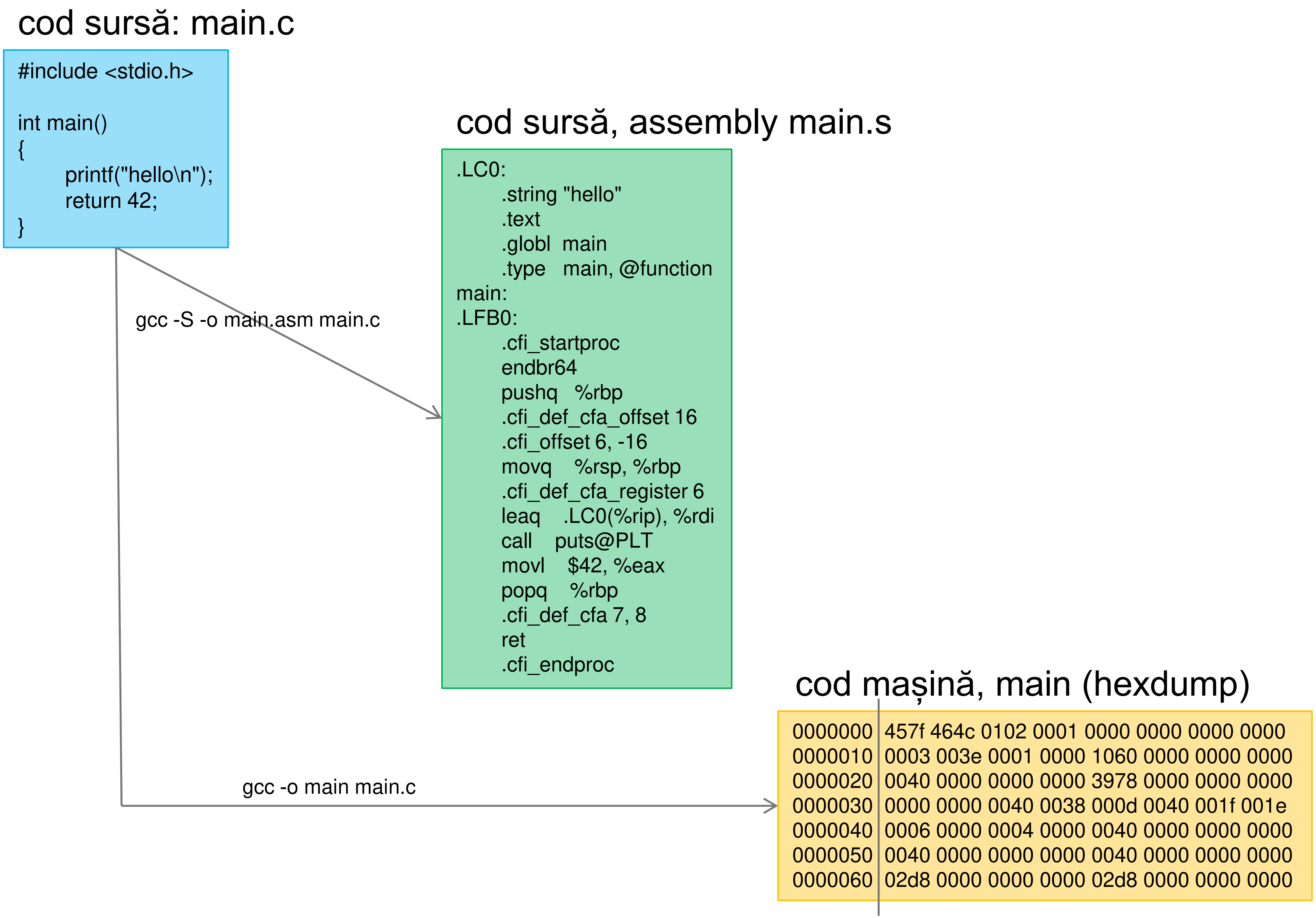
```
68 00 30 40 00 FF 15 90
5D C3 B8 4D 5A 00 00 66
33 C0 EB 34 8B 0D 3C 00
50 45 00 00 75 EA B8 0B
40 00 75 DC 33 C0 83 B9
81 E8 00 40 00 0F 95 C0
15 7C 20 40 00 59 6A FF
34 20 40 00 A3 88 33 40
30 40 00 89 01 8B 0D 38
89 01 E8 27 05 00 00 E8
40 00 00 75 0C 68 E4 12
00 68 B4 20 40 00 68 A4
59 59 85 C0 74 17 C7 45
00 00 E9 DE 00 00 00 89
33 40 00 75 18 68 A0 20
77 04 00 00 59 59 C7 05
```

```
68 00 30 40 00 FF 15 90
5D C3 B8 4D 5A 00 00 66
33 C0 EB 34 8B 0D 3C 00
50 45 00 00 75 EA B8 0B
40 00 75 DC 33 C0 83 B9
81 E8 00 40 00 0F 95 C0
15 7C 20 40 00 59 6A FF
34 20 40 00 A3 88 33 40
30 40 00 89 01 8B 0D 38
89 01 E8 27 05 00 00 E8
40 00 00 75 0C 68 E4 12
59 E8 48 05 00 00 83 3D
FF FF 15 44 20 40 00 59
E8 D4 04 00 00 A1 58 30
00 FF 35 54 30 40 00 A3
```

```
00 68 B4 20 40 00 68 A4
59 59 85 C0 74 17 C7 45
00 00 E9 DE 00 00 00 89
33 40 00 75 18 68 A0 20
77 04 00 00 59 59 C7 05
```

https://slideplayer.com/slide/4695781/

DE LA COD SURSĂ LA EXECUȚIE



cod sursă: main.c

```
#include <stdio.h>

int main()
{
	printf("hello\n");
	return 42;
}
```

gcc -S -o main.asm main.c

cod sursă, assembly main.s

```
.LC0:
	.string "hello"
	.text
	.globl  main
	.type   main, @function
main:
.LFB0:
	.cfi_startproc
	endbr64
	pushq   %rbp
	.cfi_def_cfa_offset 16
	.cfi_offset 6, -16
	movq    %rsp, %rbp
	.cfi_def_cfa_register 6
	leaq    .LC0(%rip), %rdi
	call    puts@PLT
	movl    $42, %eax
	popq    %rbp
	.cfi_def_cfa 7, 8
	ret
	.cfi_endproc
```

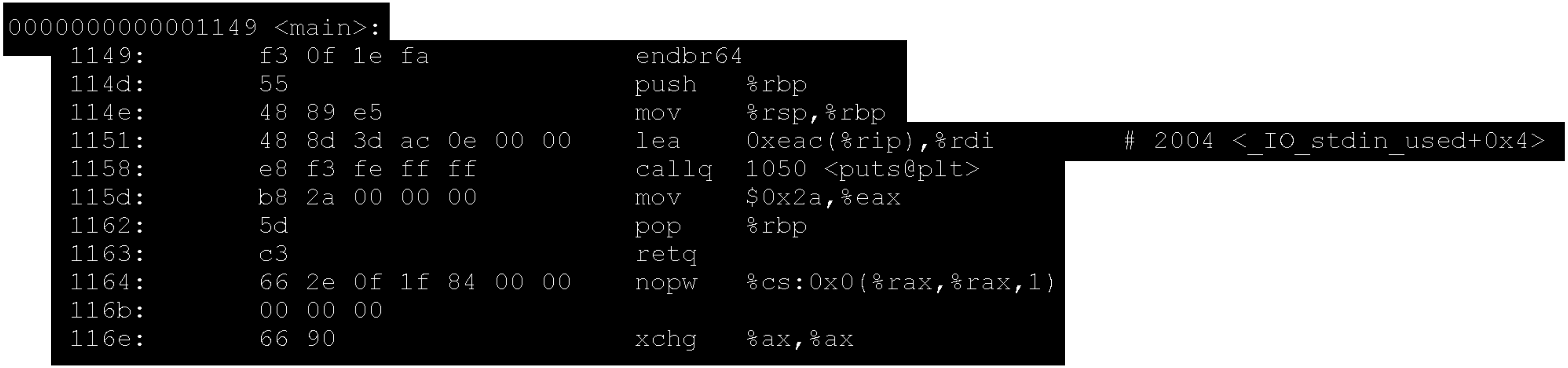
gcc -o main main.c

cod mașină, main (hexdump)

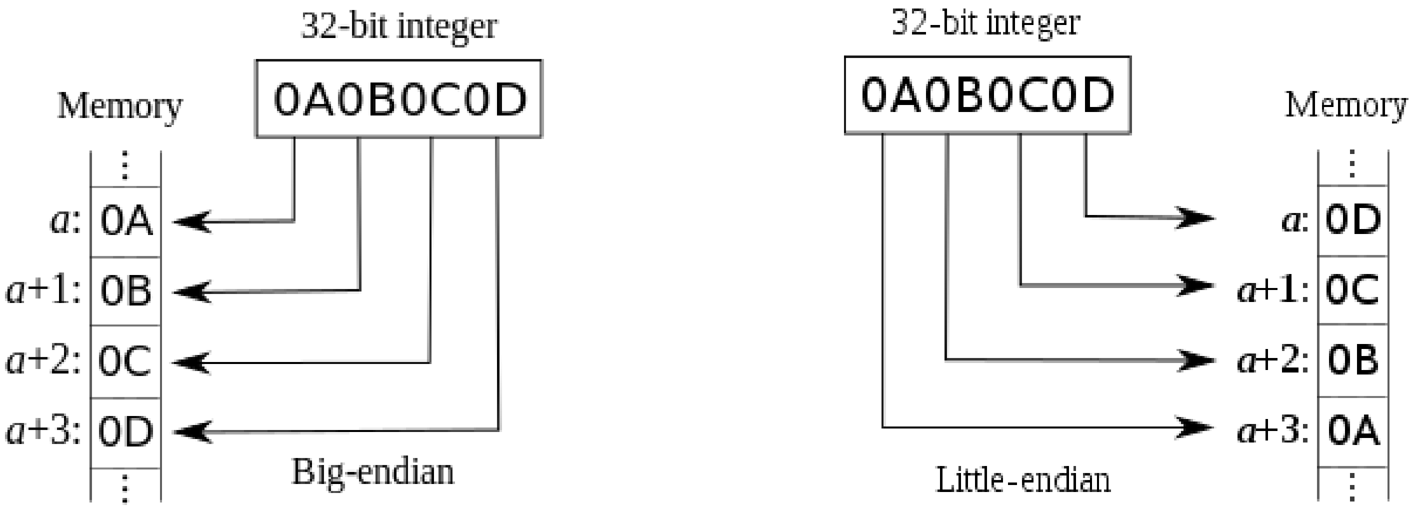
```
0000000 457f 464c 0102 0001 0000 0000 0000 0000
0000010 0003 003e 0001 0000 1060 0000 0000 0000
0000020 0040 0000 0000 0000 3978 0000 0000 0000
0000030 0000 0000 0040 0038 000d 0040 001f 001e
0000040 0006 0000 0004 0000 0040 0000 0000 0000
0000050 0040 0000 0000 0000 0040 0000 0000 0000
0000060 02d8 0000 0000 0000 02d8 0000 0000 0000
```

DE LA COD SURSĂ LA EXECUȚIE

- **objdump main**



```
0000000000001149 <main>:
    1149:       f3 0f 1e fa             endbr64
    114d:       55                      push   %rbp
    114e:       48 89 e5                mov    %rsp,%rbp
    1151:       48 8d 3d ac 0e 00 00    lea    0xeac(%rip),%rdi        # 2004 <_IO_stdin_used+0x4>
    1158:       e8 f3 fe ff ff          callq  1050 <puts@plt>
    115d:       b8 2a 00 00 00          mov    $0x2a,%eax
    1162:       5d                      pop    %rbp
    1163:       c3                      retq
    1164:       66 2e 0f 1f 84 00 00    nopw   %cs:0x0(%rax,%rax,1)
    116b:       00 00 00
    116e:       66 90                   xchg   %ax,%ax
```



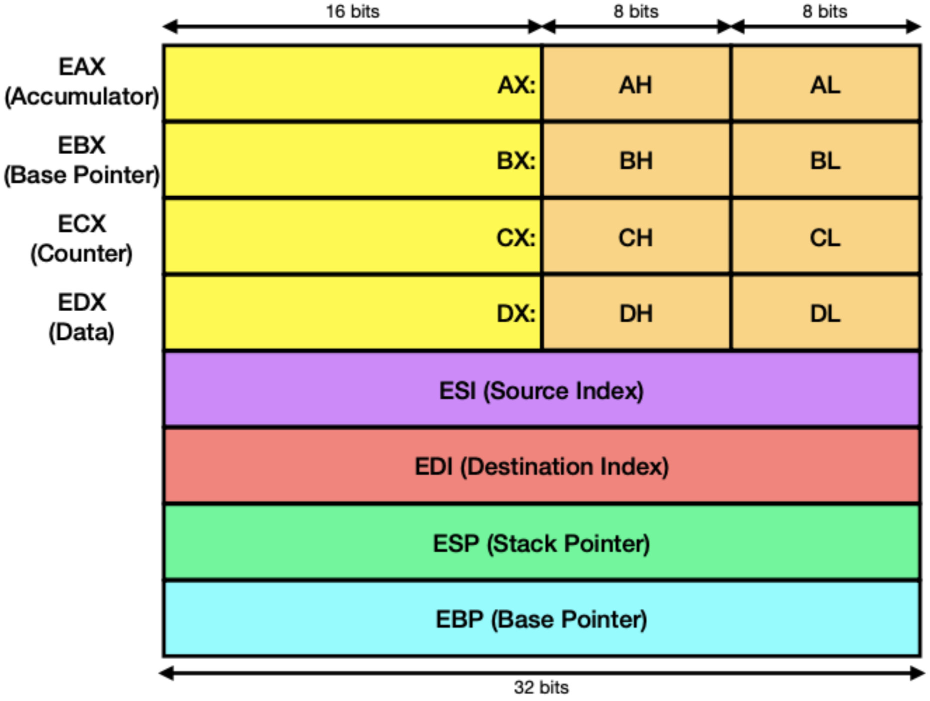
https://en.wikipedia.org/wiki/Endianness

de asemenea, observați că instrucțiunile nu sunt codate cu aceeași lungime

ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - **regiștri**
    - instrucțiuni
    - tipuri de date
    - metode de adresare a memoriei

4 bits = 1 nibble
8 bits = 1 byte
16 bits = 1 word
32 bits = 1 dword
64 bits = 1 qword



FLAGS

Instruction Pointer (IP): următoarea instrucțiune care trebuie executată

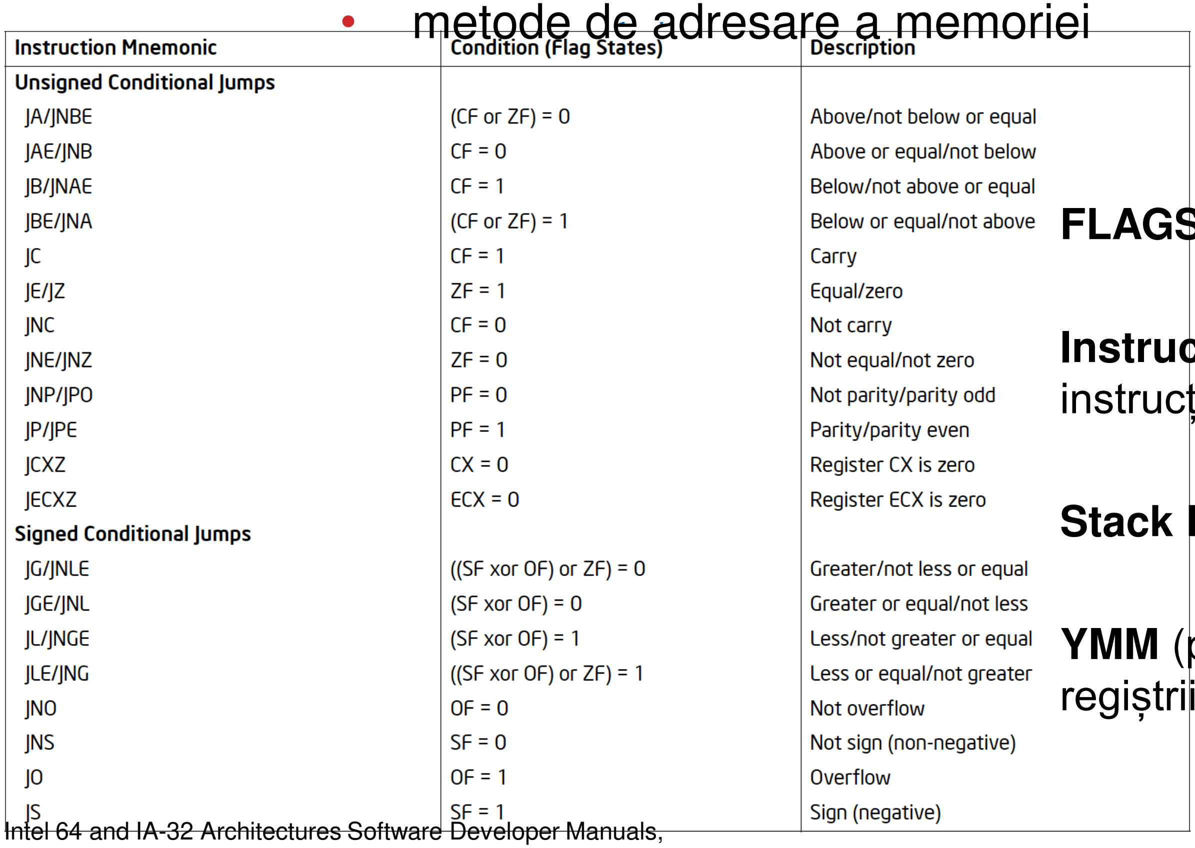
Stack Pointer (ESP): adresa stivei

YMM (pentru AVX) / **XMM** (pentru SSE): regiștrii pentru operații pe vectori

ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - **regiștri**
    - instrucțiuni
    - tipuri de date
    - metode de adresare a memoriei

4 bits = 1 nibble
8 bits = 1 byte
16 bits = 1 word
32 bits = 1 dword
64 bits = 1 qword



Instruction Mnemonic	Condition (Flag States)	Description
Unsigned Conditional Jumps		
JA/JNBE	(CF or ZF) = 0	Above/not below or equal
JAE/JNB	CF = 0	Above or equal/not below
JB/JNAE	CF = 1	Below/not above or equal
JBE/JNA	(CF or ZF) = 1	Below or equal/not above
JC	CF = 1	Carry
JE/JZ	ZF = 1	Equal/zero
JNC	CF = 0	Not carry
JNE/JNZ	ZF = 0	Not equal/not zero
JNP/JPO	PF = 0	Not parity/parity odd
JP/JPE	PF = 1	Parity/parity even
JCXZ	CX = 0	Register CX is zero
JECXZ	ECX = 0	Register ECX is zero
Signed Conditional Jumps		
JG/JNLE	((SF xor OF) or ZF) = 0	Greater/not less or equal
JGE/JNL	(SF xor OF) = 0	Greater or equal/not less
JL/JNGE	(SF xor OF) = 1	Less/not greater or equal
JLE/JNG	((SF xor OF) or ZF) = 1	Less or equal/not greater
JNO	OF = 0	Not overflow
JNS	SF = 0	Not sign (non-negative)
JO	OF = 1	Overflow
JS	SF = 1	Sign (negative)

Intel 64 and IA-32 Architectures Software Developer Manuals,
http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html

FLAGS

Instruction Pointer (IP): următoarea instrucțiune care trebuie executată

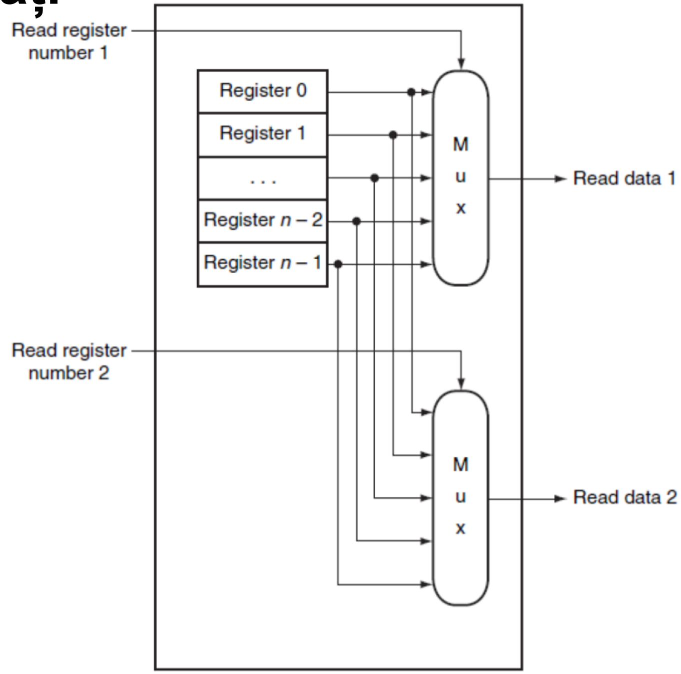
Stack Pointer (ESP): adresa stivei

YMM (pentru AVX) / **XMM** (pentru SSE): regiștrii pentru operații pe vectori

ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - **regiștri**
    - instrucțiuni
    - tipuri de date
    - metode de adresare a memoriei

- **în general, regiștrii sunt grupați și indexați**
  - **read register 1 / 2: indecșii de citire**
  - **read data 1 / 2: datele citite**
  - write register: indexul în care se scrie
  - write data: datele care se scriu

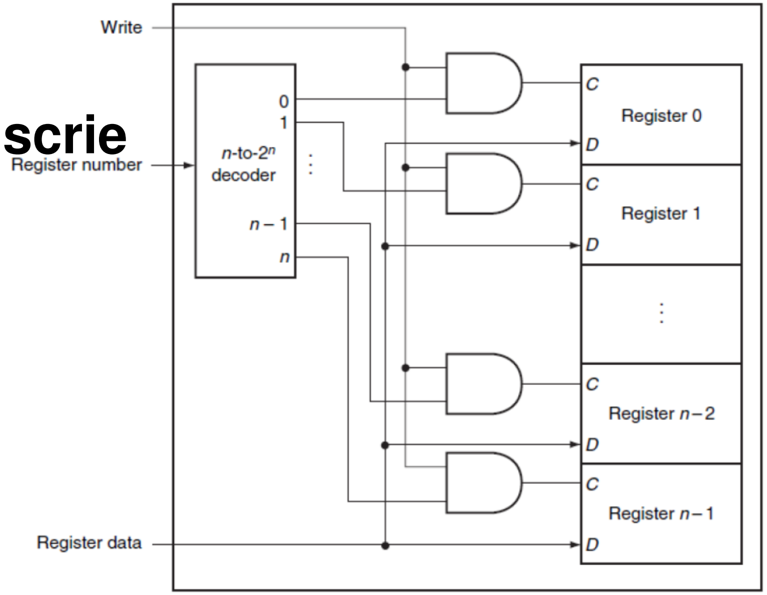


PH book, Apendix B.8

ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - **regiștri**
    - instrucțiuni
    - tipuri de date
    - metode de adresare a memoriei

- **în general, regiștrii sunt grupați și indexați**
  - read register 1 / 2: indecșii de citire
  - read data 1 / 2: datele citite
  - **write register: indexul în care se scrie**
  - **write data: datele care se scriu**



PH book, Apendix B.8

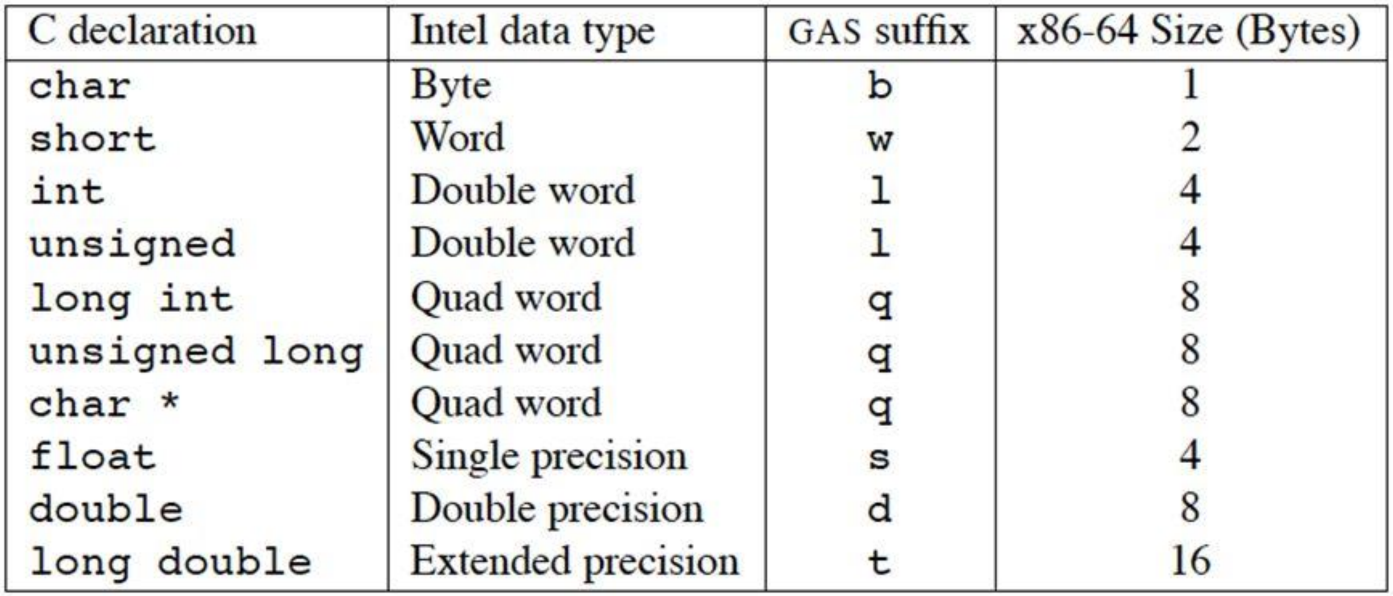
ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - regiștri
    - **instrucțiuni**
    - tipuri de date
    - metode de adresare a memoriei
  - <opcode> <listă operanzi>
    - add op1, op2 (op2 ← op2 + op1)
    - **Categorii de instrucțiuni**
      - **transferul datelor**: mov, cmov, movq, movs, movz, push, pop
      - **aritmetică și logică**: add, sub, mul, imul, div, idiv, sal, sar, shl, shr, and, or, not, xor, test, cmp
      - **controlul programului**: call, ret, j*

.

ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - regiștri
    - instrucțiuni
    - **tipuri de date**
    - metode de adresare a memoriei



C declaration	Intel data type	GAS suffix	x86-64 Size (Bytes)
`char`	Byte	b	1
`short`	Word	w	2
`int`	Double word	l	4
`unsigned`	Double word	l	4
`long int`	Quad word	q	8
`unsigned long`	Quad word	q	8
`char *`	Quad word	q	8
`float`	Single precision	s	4
`double`	Double precision	d	8
`long double`	Extended precision	t	16

* pot fi mici variații în funcție de definiții, windows vs linux etc.

https://slideplayer.com/slide/9507029/
https://www.intel.com/content/www/us/en/developer/articles/technical/size-of-long-integer-type-on-different-architecture-and-os.html
https://stackoverflow.com/questions/384502/what-is-the-bit-size-of-long-on-64-bit-windows

ARHITECTURA SETULUI DE INSTRUCȚIUNI

- **Instruction Set Arhitecture (ISA)**
  - structura sintactică și semantică a limbajului Assembly
    - regiștri
    - instrucțiuni
    - tipuri de date
    - **metode de adresare a memoriei**

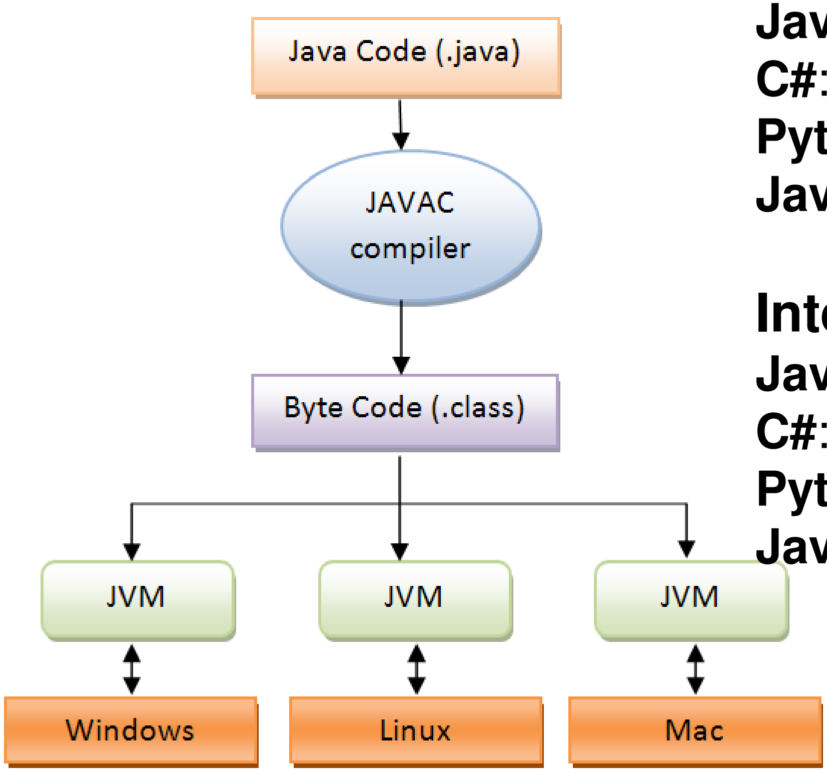
  - **adresare imediată**:
    - imediat: mov $172, %rdi
    - cu registru: mov %rcx, %rdi
    - cu memorie: mov 0x172, %rdi

  - **adresare indirectă**
    - indirect prin registru: mov (%rax), %rdi
    - indirect indexat: mov 172(%rax), %rdi
    - indirect bazat pe IP: mov 172(%rip), %rdi

  - **cazul cel mai general**: mov 172(%rdi, %rdx, 8), %rax
    - Base + Index*Scale + Displacement
    - îl aveți explicat detaliat în suportul de laborator

DE LA COD SURSĂ LA EXECUȚIE

- **excepție de la regulă**
  - bytecode (cod interpretat): instrucțiunile sunt executate de un interpretor care apoi le trimite la CPU

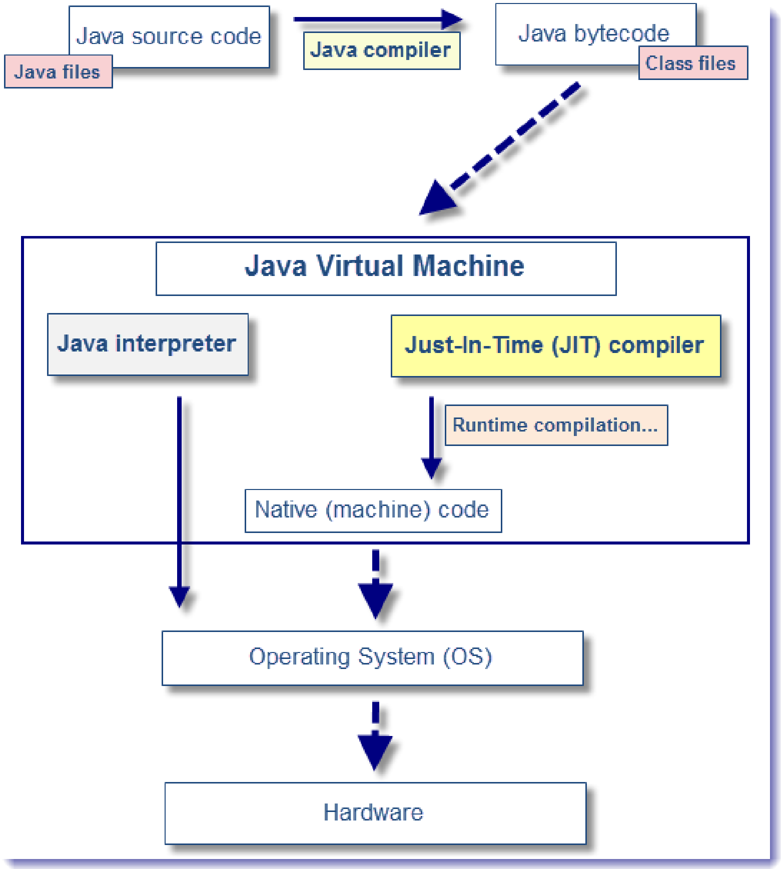


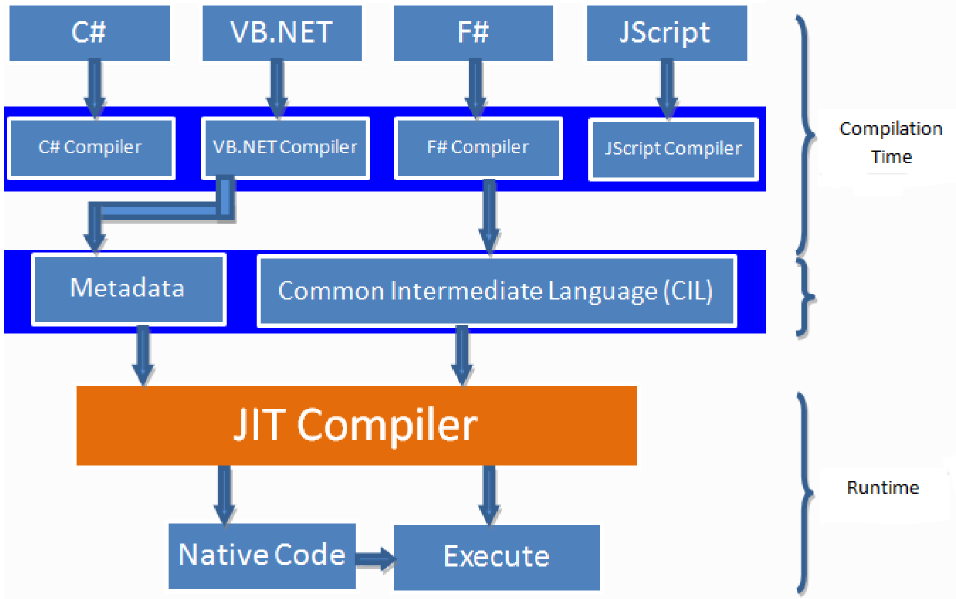
Interpreted code:
Java: java byte-code
C#: Common Intermediate Language (CIL)
Python: .py, python byte-code (fișiere .pyc)
Javascript: .js

Interpreter:
Java: Java VM
C#: Common Language Runtime (CLR) în .NET
Python: python Virtual Machine
Javascript: V8 sau Spider Monkey

DE LA COD SURSĂ LA EXECUȚIE

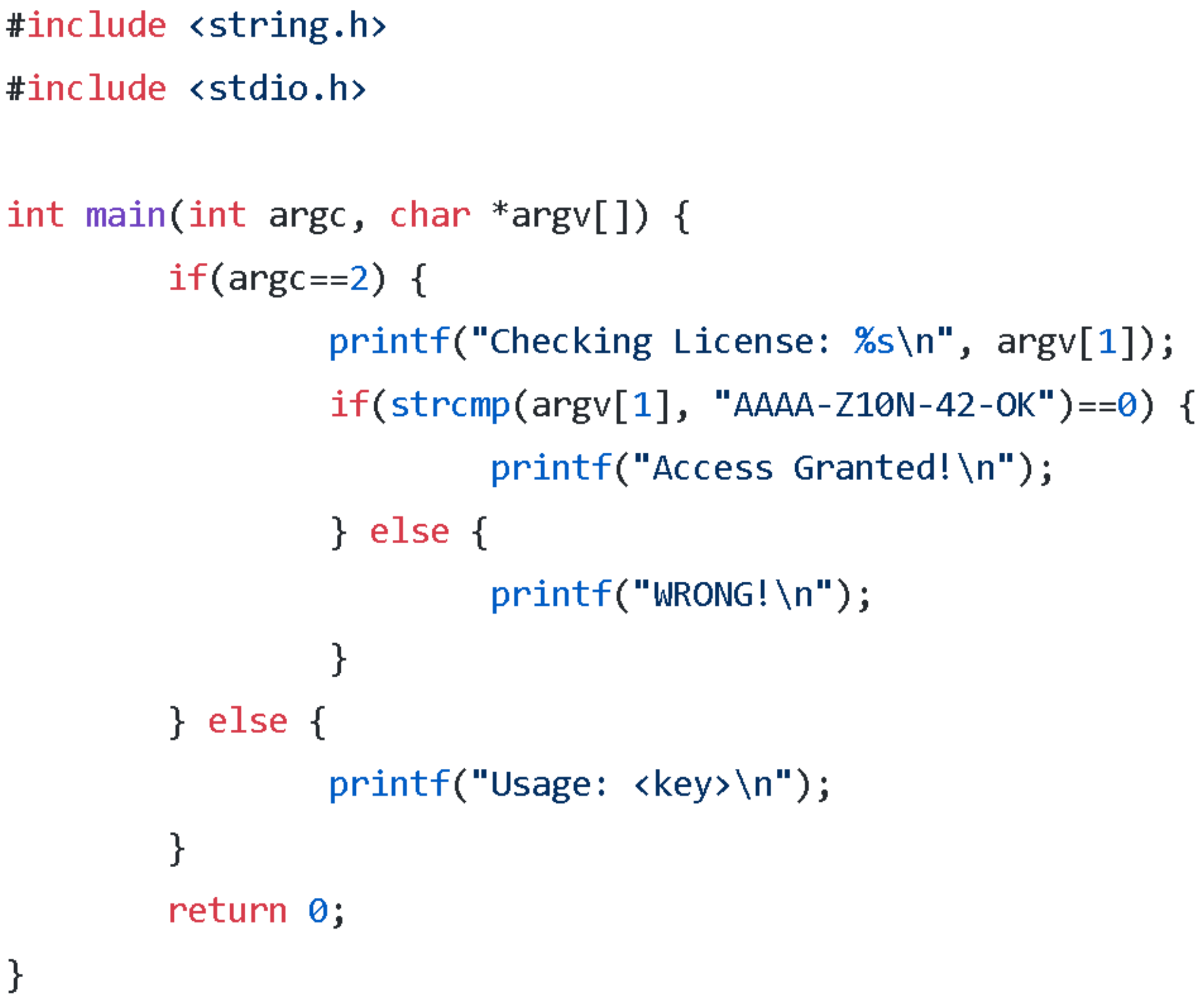
- **excepție de la regulă**
  - bytecode (cod interpretat): instrucțiunile sunt executate de un interpretor care apoi le trimite la CPU
  - totul e lent pentru că mai este un pas de procesare
  - JIT compilation (Just-In-Time compilation) ajută





UN EXEMPLU

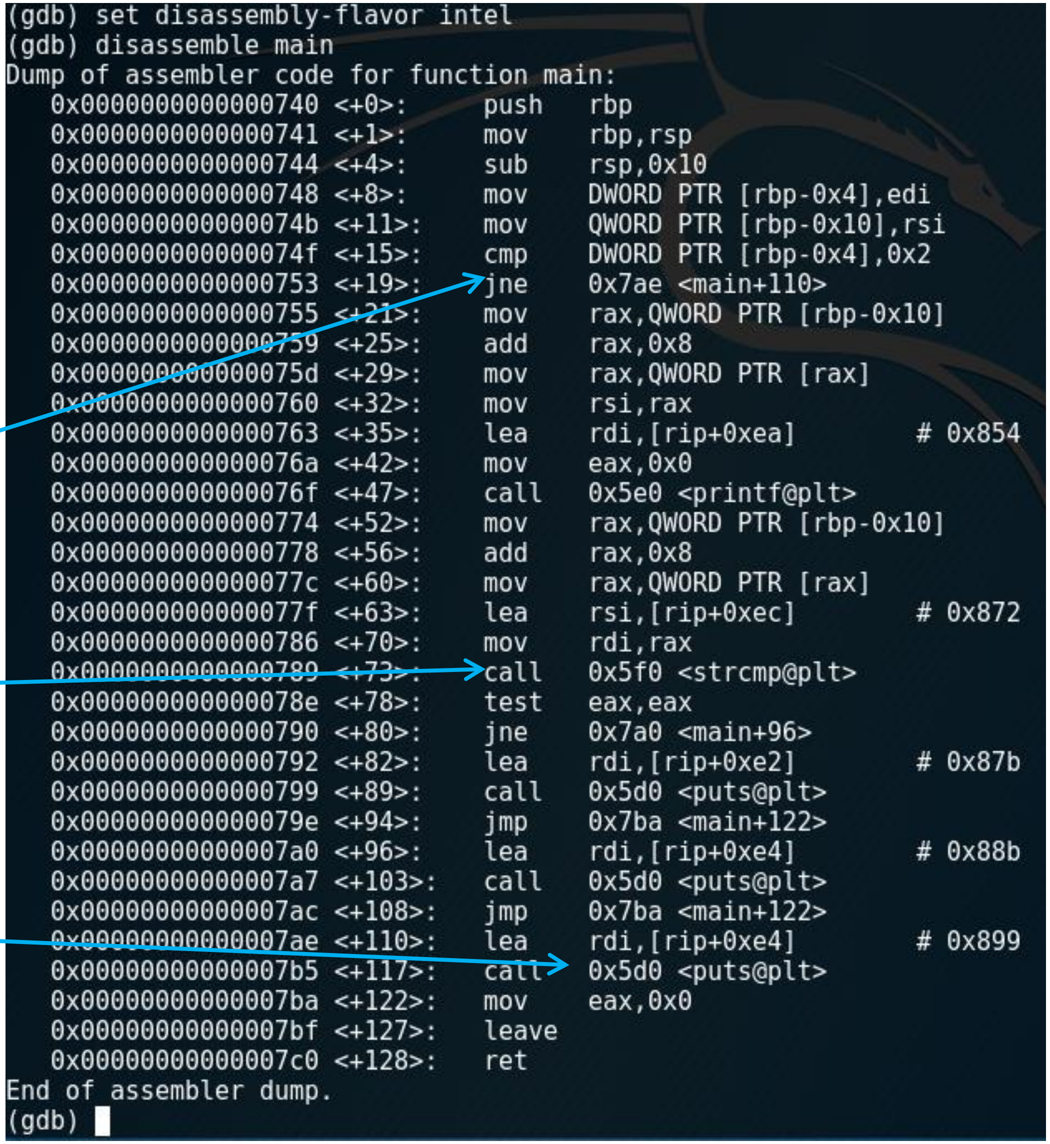
- **următorul program simplu verifică o cheie de licență**



```
#include <string.h>
#include <stdio.h>

int main(int argc, char *argv[]) {
        if(argc==2) {
                printf("Checking License: %s\n", argv[1]);
                if(strcmp(argv[1], "AAAA-Z10N-42-OK")==0) {
                        printf("Access Granted!\n");
                } else {
                        printf("WRONG!\n");
                }
        } else {
                printf("Usage: <key>\n");
        }
        return 0;
}
```

UN EXEMPLU

- **gdb checklicense**



```
(gdb) set disassembly-flavor intel
(gdb) disassemble main
Dump of assembler code for function main:
   0x0000000000000740 <+0>:     push   rbp
   0x0000000000000741 <+1>:     mov    rbp,rsp
   0x0000000000000744 <+4>:     sub    rsp,0x10
   0x0000000000000748 <+8>:     mov    DWORD PTR [rbp-0x4],edi
   0x000000000000074b <+11>:    mov    QWORD PTR [rbp-0x10],rsi
   0x000000000000074f <+15>:    cmp    DWORD PTR [rbp-0x4],0x2
   0x0000000000000753 <+19>:    jne    0x7ae <main+110>
   0x0000000000000755 <+21>:    mov    rax,QWORD PTR [rbp-0x10]
   0x0000000000000759 <+25>:    add    rax,0x8
   0x000000000000075d <+29>:    mov    rax,QWORD PTR [rax]
   0x0000000000000760 <+32>:    mov    rsi,rax
   0x0000000000000763 <+35>:    lea    rdi,[rip+0xea]        # 0x854
   0x000000000000076a <+42>:    mov    eax,0x0
   0x000000000000076f <+47>:    call   0x5e0 <printf@plt>
   0x0000000000000774 <+52>:    mov    rax,QWORD PTR [rbp-0x10]
   0x0000000000000778 <+56>:    add    rax,0x8
   0x000000000000077c <+60>:    mov    rax,QWORD PTR [rax]
   0x000000000000077f <+63>:    lea    rsi,[rip+0xec]        # 0x872
   0x0000000000000786 <+70>:    mov    rdi,rax
   0x0000000000000789 <+73>:    call   0x5f0 <strcmp@plt>
   0x000000000000078e <+78>:    test   eax,eax
   0x0000000000000790 <+80>:    jne    0x7a0 <main+96>
   0x0000000000000792 <+82>:    lea    rdi,[rip+0xe2]        # 0x87b
   0x0000000000000799 <+89>:    call   0x5d0 <puts@plt>
   0x000000000000079e <+94>:    jmp    0x7ba <main+122>
   0x00000000000007a0 <+96>:    lea    rdi,[rip+0xe4]        # 0x88b
   0x00000000000007a7 <+103>:   call   0x5d0 <puts@plt>
   0x00000000000007ac <+108>:   jmp    0x7ba <main+122>
   0x00000000000007ae <+110>:   lea    rdi,[rip+0xe4]        # 0x899
   0x00000000000007b5 <+117>:   call   0x5d0 <puts@plt>
   0x00000000000007ba <+122>:   mov    eax,0x0
   0x00000000000007bf <+127>:   leave
   0x00000000000007c0 <+128>:   ret
End of assembler dump.
(gdb) █
```

verifică dacă ceva este egal cu 2

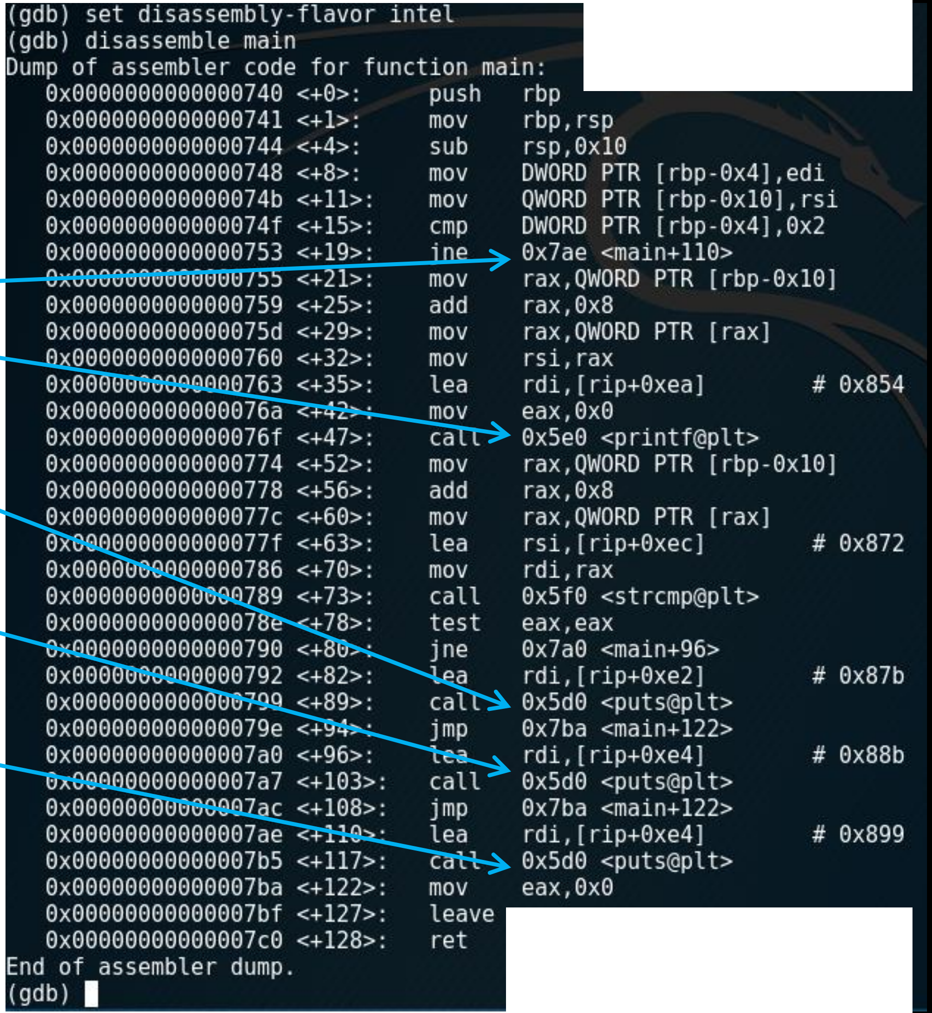
call la strcmp
apoi jne

din nou call la puts
avem asta în cod?

UN EXEMPLU

- **gdb checklicense**

```c
#include <string.h>
#include <stdio.h>

int main(int argc, char *argv[]) {
        if(argc==2) {
                printf("Checking License: %s\n", argv[1]);
                if(strcmp(argv[1], "AAAA-Z10N-42-OK")==0) {
                        printf("Access Granted!\n");
                } else {
                        printf("WRONG!\n");
                }
        } else {
                printf("Usage: <key>\n");
        }
        return 0;
}
```



```
(gdb) set disassembly-flavor intel
(gdb) disassemble main
Dump of assembler code for function main:
   0x0000000000000740 <+0>:     push   rbp
   0x0000000000000741 <+1>:     mov    rbp,rsp
   0x0000000000000744 <+4>:     sub    rsp,0x10
   0x0000000000000748 <+8>:     mov    DWORD PTR [rbp-0x4],edi
   0x000000000000074b <+11>:    mov    QWORD PTR [rbp-0x10],rsi
   0x000000000000074f <+15>:    cmp    DWORD PTR [rbp-0x4],0x2
   0x0000000000000753 <+19>:    jne    0x7ae <main+110>
   0x0000000000000755 <+21>:    mov    rax,QWORD PTR [rbp-0x10]
   0x0000000000000759 <+25>:    add    rax,0x8
   0x000000000000075d <+29>:    mov    rax,QWORD PTR [rax]
   0x0000000000000760 <+32>:    mov    rsi,rax
   0x0000000000000763 <+35>:    lea    rdi,[rip+0xea]        # 0x854
   0x000000000000076a <+42>:    mov    eax,0x0
   0x000000000000076f <+47>:    call   0x5e0 <printf@plt>
   0x0000000000000774 <+52>:    mov    rax,QWORD PTR [rbp-0x10]
   0x0000000000000778 <+56>:    add    rax,0x8
   0x000000000000077c <+60>:    mov    rax,QWORD PTR [rax]
   0x000000000000077f <+63>:    lea    rsi,[rip+0xec]        # 0x872
   0x0000000000000786 <+70>:    mov    rdi,rax
   0x0000000000000789 <+73>:    call   0x5f0 <strcmp@plt>
   0x000000000000078e <+78>:    test   eax,eax
   0x0000000000000790 <+80>:    jne    0x7a0 <main+96>
   0x0000000000000792 <+82>:    lea    rdi,[rip+0xe2]        # 0x87b
   0x0000000000000799 <+89>:    call   0x5d0 <puts@plt>
   0x000000000000079e <+94>:    jmp    0x7ba <main+122>
   0x00000000000007a0 <+96>:    lea    rdi,[rip+0xe4]        # 0x88b
   0x00000000000007a7 <+103>:   call   0x5d0 <puts@plt>
   0x00000000000007ac <+108>:   jmp    0x7ba <main+122>
   0x00000000000007ae <+110>:   lea    rdi,[rip+0xe4]        # 0x899
   0x00000000000007b5 <+117>:   call   0x5d0 <puts@plt>
   0x00000000000007ba <+122>:   mov    eax,0x0
   0x00000000000007bf <+127>:   leave
   0x00000000000007c0 <+128>:   ret
End of assembler dump.
(gdb) 
```

UN EXEMPLU

- **informațiile executabilului**
  - file checklicense

- **hex viewer**
  - hexdump –C checklicense

- **hex editor**
  - hexeditor checklicense

- **scoate toate string-urile din fișier**
  - strings checklicense

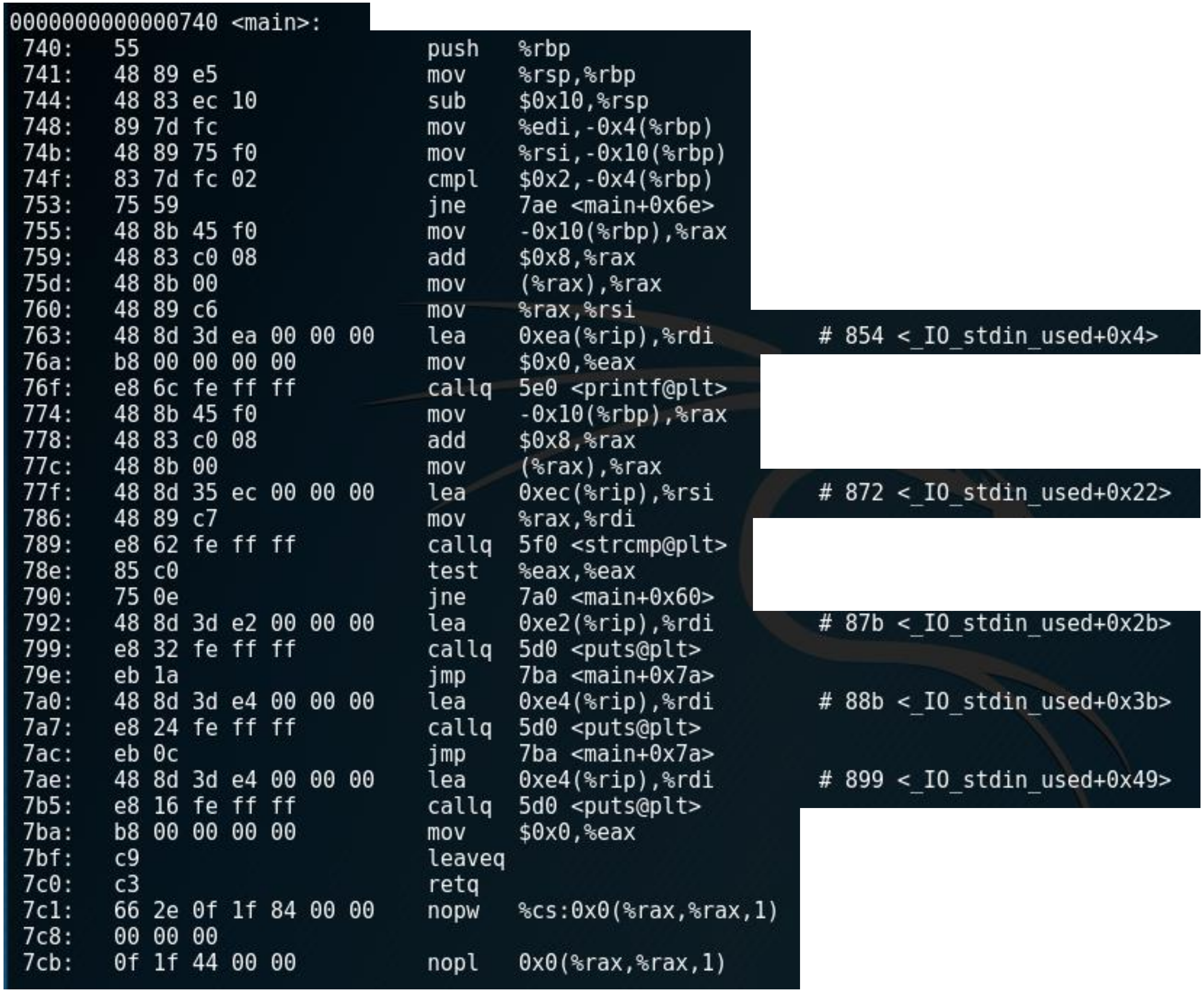
- **dump al obiectelor din fișier**
  - objdump –x checklicense

- **analiză binară avansată**
  - radare2 (r2)
  - ghidra

https://ghidra-sre.org/

UN EXEMPLU

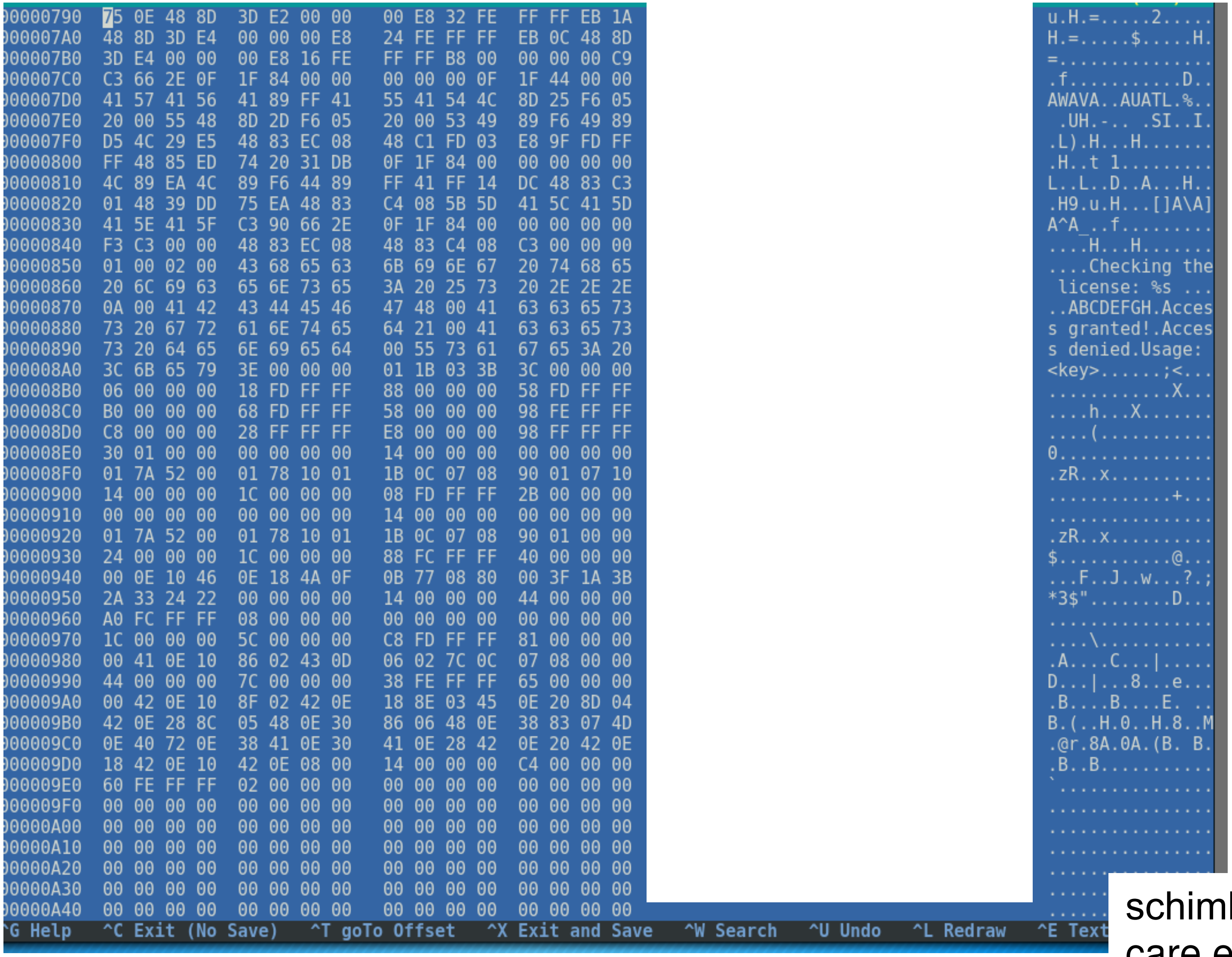
- **objdump –d checklicense**



```
0000000000000740 <main>:
 740:   55                      push   %rbp
 741:   48 89 e5                mov    %rsp,%rbp
 744:   48 83 ec 10             sub    $0x10,%rsp
 748:   89 7d fc                mov    %edi,-0x4(%rbp)
 74b:   48 89 75 f0             mov    %rsi,-0x10(%rbp)
 74f:   83 7d fc 02             cmpl   $0x2,-0x4(%rbp)
 753:   75 59                   jne    7ae <main+0x6e>
 755:   48 8b 45 f0             mov    -0x10(%rbp),%rax
 759:   48 83 c0 08             add    $0x8,%rax
 75d:   48 8b 00                mov    (%rax),%rax
 760:   48 89 c6                mov    %rax,%rsi
 763:   48 8d 3d ea 00 00 00    lea    0xea(%rip),%rdi        # 854 <_IO_stdin_used+0x4>
 76a:   b8 00 00 00 00          mov    $0x0,%eax
 76f:   e8 6c fe ff ff          callq  5e0 <printf@plt>
 774:   48 8b 45 f0             mov    -0x10(%rbp),%rax
 778:   48 83 c0 08             add    $0x8,%rax
 77c:   48 8b 00                mov    (%rax),%rax
 77f:   48 8d 35 ec 00 00 00    lea    0xec(%rip),%rsi        # 872 <_IO_stdin_used+0x22>
 786:   48 89 c7                mov    %rax,%rdi
 789:   e8 62 fe ff ff          callq  5f0 <strcmp@plt>
 78e:   85 c0                   test   %eax,%eax
 790:   75 0e                   jne    7a0 <main+0x60>
 792:   48 8d 3d e2 00 00 00    lea    0xe2(%rip),%rdi        # 87b <_IO_stdin_used+0x2b>
 799:   e8 32 fe ff ff          callq  5d0 <puts@plt>
 79e:   eb 1a                   jmp    7ba <main+0x7a>
 7a0:   48 8d 3d e4 00 00 00    lea    0xe4(%rip),%rdi        # 88b <_IO_stdin_used+0x3b>
 7a7:   e8 24 fe ff ff          callq  5d0 <puts@plt>
 7ac:   eb 0c                   jmp    7ba <main+0x7a>
 7ae:   48 8d 3d e4 00 00 00    lea    0xe4(%rip),%rdi        # 899 <_IO_stdin_used+0x49>
 7b5:   e8 16 fe ff ff          callq  5d0 <puts@plt>
 7ba:   b8 00 00 00 00          mov    $0x0,%eax
 7bf:   c9                      leaveq
 7c0:   c3                      retq
 7c1:   66 2e 0f 1f 84 00 00    nopw   %cs:0x0(%rax,%rax,1)
 7c8:   00 00 00
 7cb:   0f 1f 44 00 00          nopl   0x0(%rax,%rax,1)
```

UN EXEMPLU

- **hexeditor checklicense**



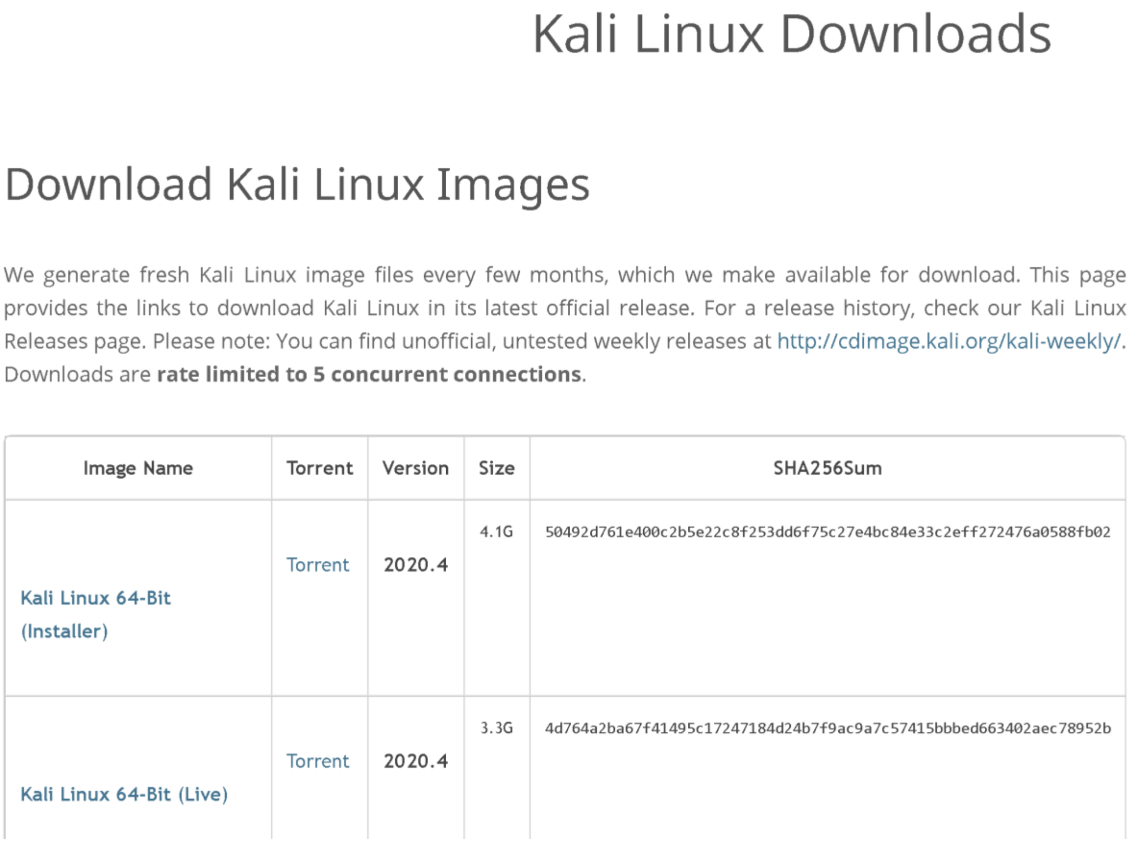
```
00000790  75 0E 48 8D  3D E2 00 00   00 E8 32 FE  FF FF EB 1A   u.H.=.....2.....
000007A0  48 8D 3D E4  00 00 00 E8   24 FE FF FF  EB 0C 48 8D   H.=.....$.....H.
000007B0  3D E4 00 00  00 E8 16 FE   FF FF B8 00  00 00 00 C9   =...............
000007C0  C3 66 2E 0F  1F 84 00 00   00 00 00 0F  1F 44 00 00   .f..........D..
000007D0  41 57 41 56  41 89 FF 41   55 41 54 4C  8D 25 F6 05   AWAVA..AUATL.%..
000007E0  20 00 55 48  8D 2D F6 05   20 00 53 49  89 F6 49 89    .UH.-.. .SI..I.
000007F0  D5 4C 29 E5  48 83 EC 08   48 C1 FD 03  E8 9F FD FF   .L).H...H.......
00000800  FF 48 85 ED  74 20 31 DB   0F 1F 84 00  00 00 00 00   .H..t 1.........
00000810  4C 89 EA 4C  89 F6 44 89   FF 41 FF 14  DC 48 83 C3   L..L..D..A...H..
00000820  01 48 39 DD  75 EA 48 83   C4 08 5B 5D  41 5C 41 5D   .H9.u.H...[]A\A]
00000830  41 5E 41 5F  C3 90 66 2E   0F 1F 84 00  00 00 00 00   A^A_..f.........
00000840  F3 C3 00 00  48 83 EC 08   48 83 C4 08  C3 00 00 00   ....H...H.......
00000850  01 00 02 00  43 68 65 63   6B 69 6E 67  20 74 68 65   ....Checking the
00000860  20 6C 69 63  65 6E 73 65   3A 20 25 73  20 2E 2E 2E    license: %s ...
00000870  0A 00 41 42  43 44 45 46   47 48 00 41  63 63 65 73   ..ABCDEFGH.Acces
00000880  73 20 67 72  61 6E 74 65   64 21 00 41  63 63 65 73   s granted!.Acces
00000890  73 20 64 65  6E 69 65 64   00 55 73 61  67 65 3A 20   s denied.Usage: 
000008A0  3C 6B 65 79  3E 00 00 00   01 1B 03 3B  3C 00 00 00   <key>......;<...
000008B0  06 00 00 00  18 FD FF FF   88 00 00 00  58 FD FF FF   ............X...
000008C0  B0 00 00 00  68 FD FF FF   58 00 00 00  98 FE FF FF   ....h...X.......
000008D0  C8 00 00 00  28 FF FF FF   E8 00 00 00  98 FF FF FF   ....(...........
000008E0  30 01 00 00  00 00 00 00   14 00 00 00  00 00 00 00   0...............
000008F0  01 7A 52 00  01 78 10 01   1B 0C 07 08  90 01 07 10   .zR..x..........
00000900  14 00 00 00  1C 00 00 00   08 FD FF FF  2B 00 00 00   ............+...
00000910  00 00 00 00  00 00 00 00   14 00 00 00  00 00 00 00   ................
00000920  01 7A 52 00  01 78 10 01   1B 0C 07 08  90 01 00 00   .zR..x..........
00000930  24 00 00 00  1C 00 00 00   88 FC FF FF  40 00 00 00   $...........@...
00000940  00 0E 10 46  0E 18 4A 0F   0B 77 08 80  00 3F 1A 3B   ...F..J..w...?.;
00000950  2A 33 24 22  00 00 00 00   14 00 00 00  44 00 00 00   *3$"........D...
00000960  A0 FC FF FF  08 00 00 00   00 00 00 00  00 00 00 00   ................
00000970  1C 00 00 00  5C 00 00 00   C8 FD FF FF  81 00 00 00   ....\...........
00000980  00 41 0E 10  86 02 43 0D   06 02 7C 0C  07 08 00 00   .A....C...|.....
00000990  44 00 00 00  7C 00 00 00   38 FE FF FF  65 00 00 00   D...|...8...e...
000009A0  00 42 0E 10  8F 02 42 0E   18 8E 03 45  0E 20 8D 04   .B....B....E. ..
000009B0  42 0E 28 8C  05 48 0E 30   86 06 48 0E  38 83 07 4D   B.(..H.0..H.8..M
000009C0  0E 40 72 0E  38 41 0E 30   41 0E 28 42  0E 20 42 0E   .@r.8A.0A.(B. B.
000009D0  18 42 0E 10  42 0E 08 00   14 00 00 00  C4 00 00 00   .B..B...........
000009E0  60 FE FF FF  02 00 00 00   00 00 00 00  00 00 00 00   `...............
000009F0  00 00 00 00  00 00 00 00   00 00 00 00  00 00 00 00   ................
00000A00  00 00 00 00  00 00 00 00   00 00 00 00  00 00 00 00   ................
00000A10  00 00 00 00  00 00 00 00   00 00 00 00  00 00 00 00   ................
00000A20  00 00 00 00  00 00 00 00   00 00 00 00  00 00 00 00   ................
00000A30  00 00 00 00  00 00 00 00   00 00 00 00  00 00 00 00   .....
00000A40  00 00 00 00  00 00 00 00   00 00 00 00  00 00 00 00   .....
^G Help   ^C Exit (No Save)   ^T goTo Offset   ^X Exit and Save   ^W Search   ^U Undo   ^L Redraw   ^E Text
```

schimbăm JNE?
care este noul OPCODE
pentru noua instrucțiune?

Intel 64 and IA-32 Architectures Software Developer Manuals,
http://www.intel.com/content/www/us/en/processors/architectures-software-developer-manuals.html

UN EXEMPLU

- **ce am făcut?**
  - am modificat, permanent, fișierul binar
  - cum ne putem da seama că un fișier a fost modificat?



Kali Linux Downloads

Download Kali Linux Images

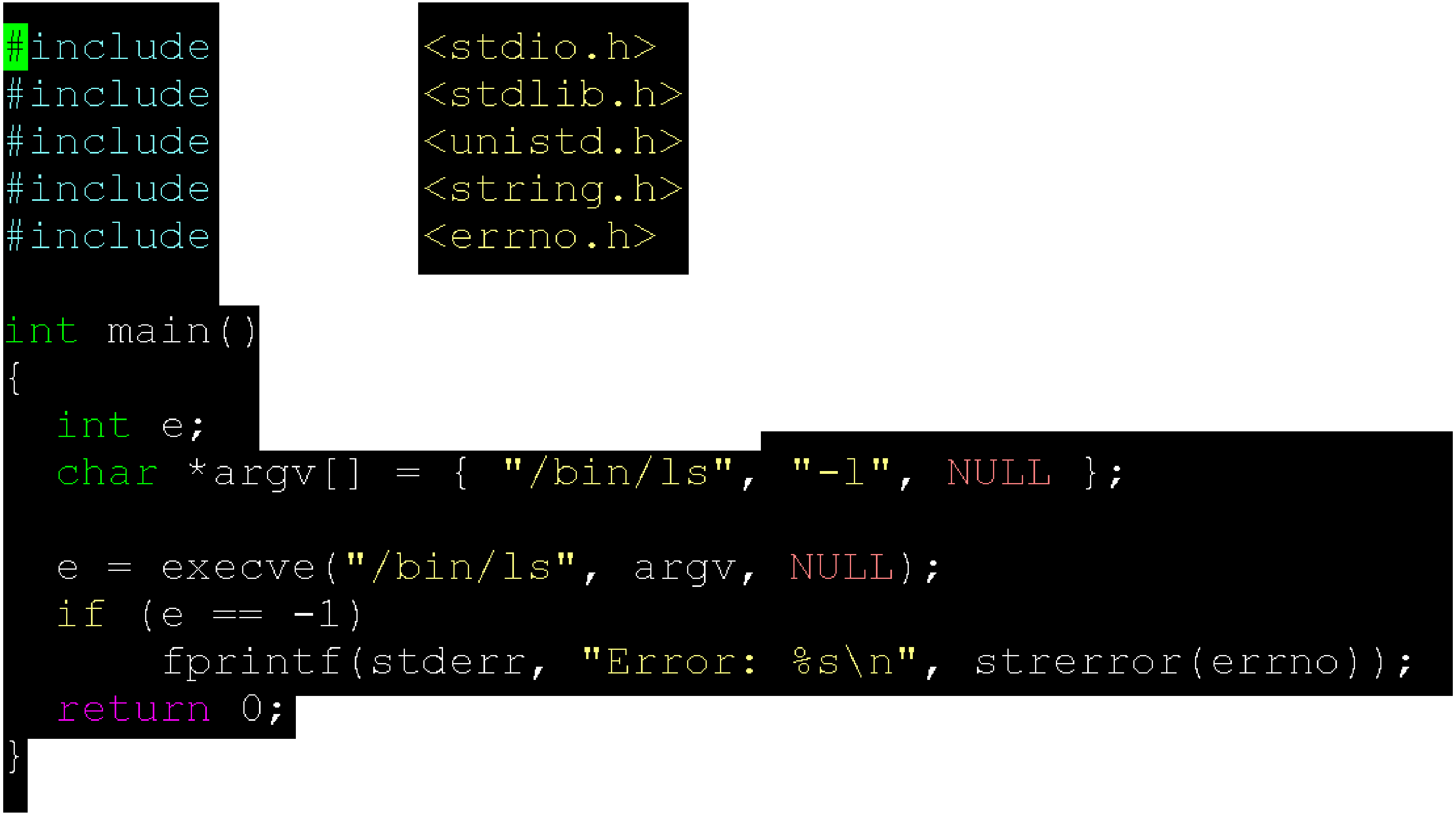
We generate fresh Kali Linux image files every few months, which we make available for download. This page provides the links to download Kali Linux in its latest official release. For a release history, check our Kali Linux Releases page. Please note: You can find unofficial, untested weekly releases at http://cdimage.kali.org/kali-weekly/. Downloads are **rate limited to 5 concurrent connections**.

Image Name	Torrent	Version	Size	SHA256Sum
Kali Linux 64-Bit (Installer)	Torrent	2020.4	4.1G	50492d761e400c2b5e22c8f253dd6f75c27e4bc84e33c2eff272476a0588fb02
Kali Linux 64-Bit (Live)	Torrent	2020.4	3.3G	4d764a2ba67f41495c17247184d24b7f9ac9a7c57415bbbed663402aec78952b

https://www.kali.org/downloads/

EXECUȚIA DATELOR

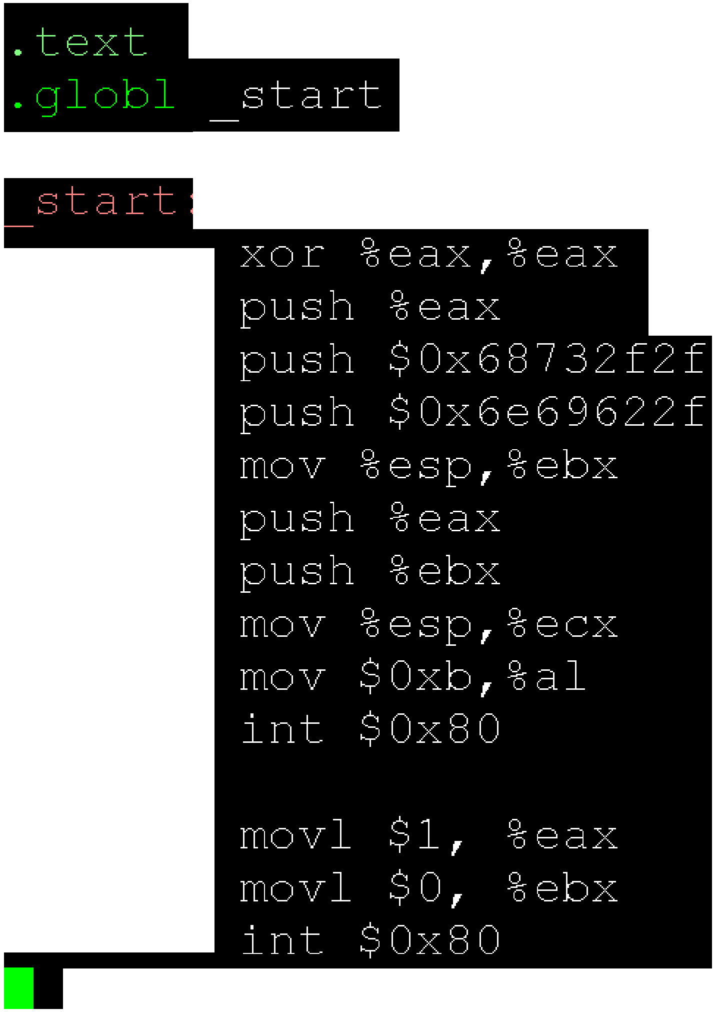
- fie următorul program foarte simplu (shellcode.c)



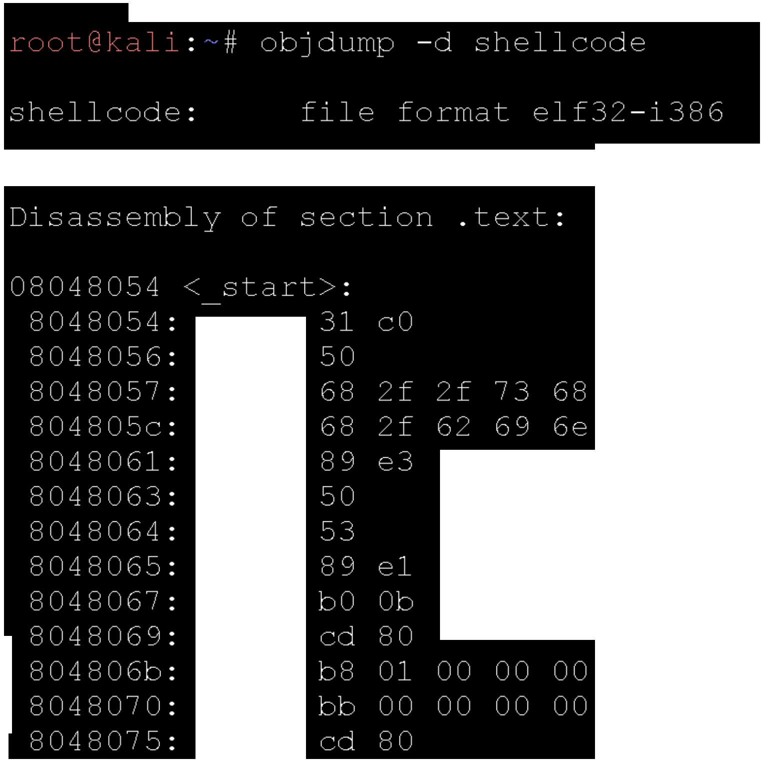
```
#include        <stdio.h>
#include        <stdlib.h>
#include        <unistd.h>
#include        <string.h>
#include        <errno.h>

int main()
{
  int e;
  char *argv[] = { "/bin/ls", "-l", NULL };

  e = execve("/bin/ls", argv, NULL);
  if (e == -1)
      fprintf(stderr, "Error: %s\n", strerror(errno));
  return 0;
}
```

EXECUȚIA DATELOR

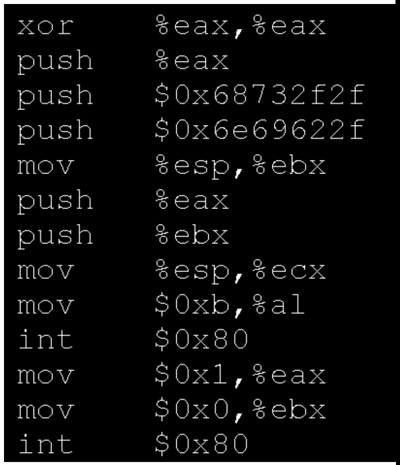
- **același program în Assembly**



```
.text
.globl _start

_start:
        xor %eax,%eax
        push %eax
        push $0x68732f2f
        push $0x6e69622f
        mov %esp,%ebx
        push %eax
        push %ebx
        mov %esp,%ecx
        mov $0xb,%al
        int $0x80

        movl $1, %eax
        movl $0, %ebx
        int $0x80
```



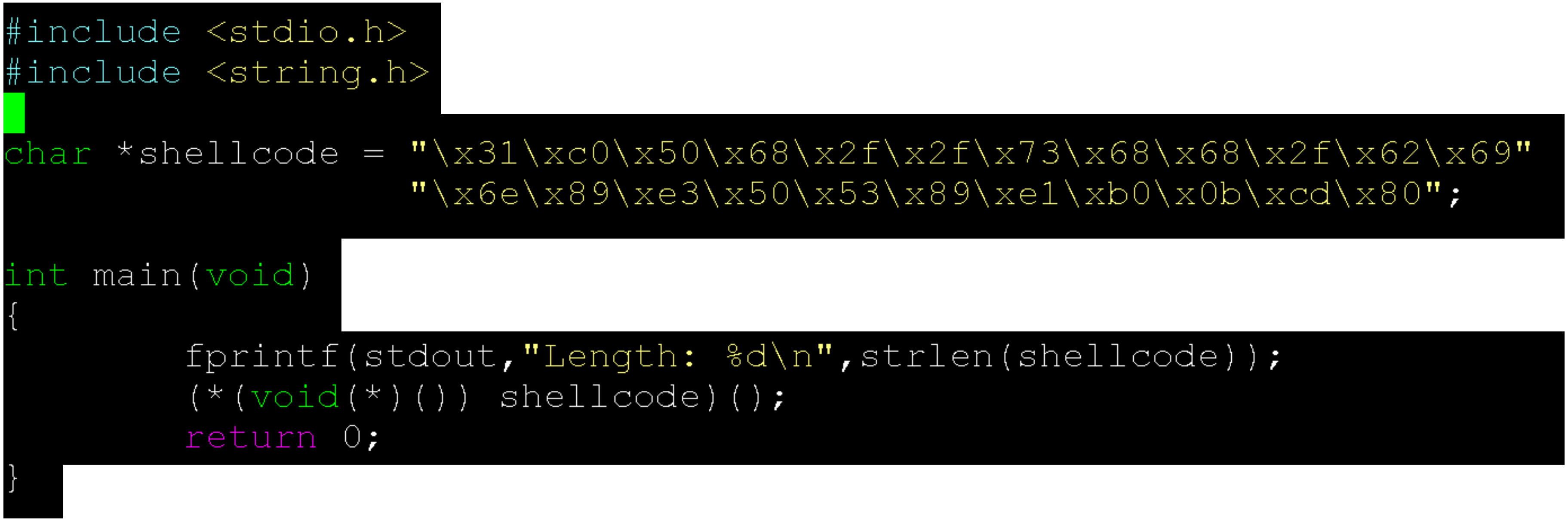
```
root@kali:~# objdump -d shellcode

shellcode:     file format elf32-i386


Disassembly of section .text:

08048054 <_start>:
 8048054:       31 c0
 8048056:       50
 8048057:       68 2f 2f 73 68
 804805c:       68 2f 62 69 6e
 8048061:       89 e3
 8048063:       50
 8048064:       53
 8048065:       89 e1
 8048067:       b0 0b
 8048069:       cd 80
 804806b:       b8 01 00 00 00
 8048070:       bb 00 00 00 00
 8048075:       cd 80
```



```
xor    %eax,%eax
push   %eax
push   $0x68732f2f
push   $0x6e69622f
mov    %esp,%ebx
push   %eax
push   %ebx
mov    %esp,%ecx
mov    $0xb,%al
int    $0x80
mov    $0x1,%eax
mov    $0x0,%ebx
int    $0x80
```

EXECUȚIA DATELOR

- **un program echivalent**



```
#include <stdio.h>
#include <string.h>

char *shellcode = "\x31\xc0\x50\x68\x2f\x2f\x73\x68\x68\x2f\x62\x69"
                  "\x6e\x89\xe3\x50\x53\x89\xe1\xb0\x0b\xcd\x80";

int main(void)
{
        fprintf(stdout,"Length: %d\n",strlen(shellcode));
        (*(void(*)()) shellcode)();
        return 0;
}
```

aceste programe nu mai pot rula pe sisteme de operare moderne

- Data Execution Prevention (DEP) e activ